SENSOPAC

SENSOrimotor structuring of Perception and Action for emerging Cognition

A. Arleo, M. Arnold, D. Cohen, E. D'Angelo, C. De Zeeuw, R. Johansson, H. Jörntell, E. Ros, P. van der Smagt, S. Vijayakumar, D. Wolpert

The SENSOPAC project combines machine learning techniques and modelling of biological systems to develop a machine capable of abstracting cognitive notions from sensorimotor relationships during interactions with its environment, and of generalizing this knowledge to novel situations. The machine, through data-driven methods, aims to discover the sensorimotor relationships and consequently learn the intrinsic structure of predictive and causal relationships that govern movement systems. In particular, SENSOPAC will learn robot dynamic models combined with sensory causal relationships in a haptic exploration task, in order to *grasp* and *decide*. Detailed neural models of key brain areas will be embedded into functional models of perception, decision making, planning, and control, effectively bridging and contributing to Neuroscience and Engineering.

A mathematically consistent large-scale model of the key cerebellar circuitry (with emphasis on cerebellar microzones) will act as bridge in transferring computational and functional principles of areas which we identify as the seat for predictive representations, context estimation and adaptive control to bio-inspired implementations of planning and control in a antagonistic, biomimetic hand-arm robotic system.

Rich sensory feedback including tactile sensory arrays, proprioceptive feedback, and motor command afferents will be employed for manipulation tasks under various contexts – allowing us to study efficient representation, encoding/decoding mechanisms and abstractions; both in human haptic manipulation as well as artificial robotic sensor systems.

A systematic and integrated approach to studying active sensing and motor control in animals in a hierarchy of defined tasks will offer insights into skilled behaviour that will lead to fruitful applications of bio-inspired mechanisms for perception, cognition and intelligent control.

The project relies on the synergy between multiple scientific institutions who are leaders in their fields, building on interaction between neuroscience experimentalists, theoreticians, and roboticists, leading to a complete artificial cognitive system using biomimetic actuation, and bio-inspired sensing.

The overall aims of the SENSOPAC project are to:

- Develop real-time neuromorphic and computing platforms for cognitive robotics;
- Develop methodologies to investigate cognition in the brain;
- Build a physical system for haptic cognition;
- Understand the sensorimotor foundation of perception and cognition.

SENSOPAC Partners concentrate on

- **neuroscience** (BIU, ERASMUS, LUND, PAVIA, UMEA, UPMC),
- **robotics, machine learning, sensorimotor system** (DLR, UCAM, UEDIN), and
- **spiking network models** (UGR, ALTJIRA).